RADAR IN THE ROYAL AUSTRALIAN NAVY

Introduction

The information contained in this article, and those intended for publication in a later issue of the *Journal of Australian Naval History* has been contributed, in the main, by those ex-RAN personnel who were closely involved in the development, manufacture, repair and use of the then highly secret technology during the years of World War 2 and immediately afterwards.{ In their recollection of events which occurred up to sixty-five years previously, it is reasonable to expect aberrations occasionally by some of the contributors.} [We can't publish an article in the *Journal* that is based on recollection. It needs to be capable of being used by researchers, so we need to quote chapter and verse, indicating where the correspondents' memories may have erred.]

The concept of radar had been enunciated by the German physicist Heinrich Hertz in 1888, and it was later demonstrated in Germany in the early 1900s. [endnote required] However, nothing was done then to develop the concept, because the technology to do so did not exist. During the 1920s and 1930s the use of wireless telegraphy and wireless telephony grew dramatically, largely due to the invention and use of the thermionic valve and its derivatives. [which made what difference?] This technology was the basis for the concept of radar becoming a reality. Impending European hostilities during the 1930s added urgency to the development of the concept into a workable device, which could provide a decided military advantage to its possessors. By the mid 1930s, radar was at last becoming a reality, after a gestation period of some 50 years, but the technology then, compared with the mature product we now see after a further 50 years of development, was quite Stone Age.

Although various experimental models of radar sets had been produced since mid-1935, possibly the first successfully deployed system was the UK-developed Chain Home Radio Location network, which commenced secret operations in July 1937. Successful trials subsequently led to the establishment of 20 Radio Direction Finding (RDF – the initial British acronym for radar) stations across southern England. [endnote required] Because of the limitations of the vacuum tube technology it employed, the Chain Home radar operated at a frequency of 25 MHz, a wavelength of 12 metres. [what is the significance of these facts?] It was only a few years later [when?]that the British invented the cavity magnetron resonator, which could produce high power pulses at a frequency of 10,000 MHz, a wavelength of 3 centimetres. A pulsed wavelength of 3 centimetres gave a far more accurate definition of range and bearing of a target than that of a longer wavelength pulse. This device, when used as the transmitter in conjunction with the US-developed klystron local oscillator, was a quantum leap forward in radar technology, and placed the Allied military far ahead of its Axis opponents in the science of radar assisted weaponry. [Yet how come the German pocket battleships had the *Dt-geraet* gunnery radar in 1939, also useful in surface search out to 18.5 nm, well ahead of any British ships? Dudley Pope, *The Battle of the River Plate*, P.49]

In reading the examples which follow, this point of the primitive state of the art should be kept in mind. There was no Google to list thousands of

references for the design teams to use. [Find a different analogy]The computer was a futuristic dream, and all design calculations were done by the design teams using standard mathematical formulae, pen, paper and active brain power. A high level of secrecy was essential, which militated against open communication of new ideas. There was no Dick Smith or Tandy available to pick up complete units to replace and repair a fault. [Don't like this either. I think you mean that spares and repair parts had to be hand made to order.] An Avometer, soldering iron, a few spare 'tubes' and lots of trial and error were the standard tool kit for the maintenance mechanics.

In combat zones under darkened ship conditions, it was common for operational and maintenance work to be done in restricted light in a confined cabin with ambient temperatures of 40 degrees Celsius plus, with the unfortunate personnel occasionally retching a previous meal into a bucket as the ship rolled and pitched in heavy seas. Circuit diagrams and maintenance manuals were shipped anything up to six months after the equipment had been commissioned. Yet despite all these barriers, [by when?] the Royal Australian Navy (RAN) had a powerful pantry of equipment and the innovative human skills to allow radar's effective use in many different circumstances, as the stories which follow illustrate.

Radar Basics

For most of those reading these Radar and related articles, the concept of the technology will be familiar. However, a short refresher course to explain some of the principles which led to early radar design would be appropriate.

Radar employs electomagnetic waves, which have a velocity of 300 million metres per second. The method of measuring the distance between the transmitter and an object from which the transmitted energy has been reflected is to multiply the velocity of the electomagnetic waves by half the time elapsed from the transmission to reception of the echo, as the energy has had to travel twice the distance. To illustrate, if a pulse of electromagnetic energy is transmitted and the returned echo comes in 50 microseconds, the formula is d = 3 x 10 to the power of 8, x 50 times 10 to the power of minus 6 =15,000 ÷ 2 = 7.5 Km. The target is 7.5 Km away from the transmitter.

If the target has radial velocity relative to the transmitter then the returned echo exhibits Doppler Effect – a small shift in the received frequency from that transmitted. As an example, at an operating frequency of 10 GHz (10,000 MHz or 3 centimetre wavelength) a radial velocity of 1 nautical mile (1.883 kilometres) per hour provides a Doppler frequency shift of 34 Hz. It should be noted however that the Doppler Effect occurs only when there is a radial difference between the Radar set and the target. If both the Radar set and the target are travelling in a straight line at the same speed, Doppler effect will be zero because the relative distance separation remains constant, and thus no frequency shift. As well, if the target is moving in a circular path of constant radius about the Radar set, again there will be no frequency change, thus no Doppler effect.

The relationship between frequency, wavelength and velocity is constant where wavelength = velocity ÷ frequency. As an example, a wavelength of 30

centimetres will be derived from a velocity of 3 x 10 to the power of 8 ÷ by 1,000 MHz (1,000 X 10 to the power of 6.)

Again for the benefit of those not familiar with Radar, following are brief explanations of some of the words and terms used in these articles:

'A' scan oscilloscope	This is a single line horizontal trace on a cathode ray (CRO). At the left hand end, the large vertical pulse indicates the initial transmission signal. To the right along the trace, a returned echo is shown as another smaller vertical pulse.
Klystron (see explanation	Using the superhetrodyne principle of radio reception of this), the klystron was used initially as a local oscillator. As the technology developed, more powerful klystrons were developed and used as transmitters.
Lantern	Imagine an old fashioned cylindrically shaped lantern, but much larger. In this on the mast would be housed the Radar antenna, and in some cases much of the transmitting and receiving equipment.
Magnetron	This was one of the main transmitters. It could produce electromagnetic signals at frequencies between 10,000 and 3,000 MHz, for pulse durations of less than 1 microsecond, at pulse repetition rates of hundreds per second and with peak power outputs of hundreds of watts.
Modulator	This is simply the device which regulates the frequency, and sometimes the duration of, the Radar transmission pulses
PPI	Plan Position Indicator was a circular Radar display (a modified cathode ray oscilloscope), with the source being at the centre of the circle. As the transmitter pulsed, a representative trace was projected on the screen emanating from the centre and extending to the periphery of the screen. A returned echo would be seen as a bright spot on the trace. As the antenna rotated, the PPI trace would rotate in synchronism. Thus not only the range of the target could be seen on the calibrated scale, but also its orientation in relation to ships head, of if desired, in relation to a fixed bearing such as magnetic or true north. Variations of this allowed the presentation of slant range of aircraft echos. Thus range, azimuth and altitude of aircraft could be quickly determined.
PRF	Simply, pulse repetition frequency, or the number of transmitted pulses each second. These varied between Radars, but a PRF of 500 was typical. [Why is this important? I know, but will the readers?]

Sector sweep rotation, some models sweeps of a selected	Refer to PPI. Instead of a 360 degree continuous were designed to allow backwards and forwards sector, e.g. 20 degrees both sides of ship's head
Superhetrodyne principle made more reliable by different frequency, and reflected echo signal of a be mixed with a klystron There would be 4 resultant MHz) and the difference (9 amplification would produce displayed echo signal.	Amplification of electromagnetic signals is mixing the desired signal with one at a slightly by selecting the resultant difference. Thus the magnetron transmission at 10,000 MHz could generated local signal of, say, 10,009 MHz. signals i.e. the original two, the sum (20,009 MHz). Selection of the 9 MHz for further the best frequency to be used to create the
Thermionic valve turn was the today in radios, looked like a was that a the heated cathode, an electric signal cathode and the anode, applied, would attract the amplitude of the signal magnified when seen at the device. The distance which anode was a factor which question.	This was the forerunner to the transistor which in forerunner to integrated circuits, used in the millions TV, mobile telephones etc. In appearance, generally it normal electric light globe. The principle of operation constant stream of electrons would be emitted from and the quantity of these electrons would be varied by applied to the grid, placed physically between the which because it had a high tension voltage cathode emitted electrons. In this process, the coming in to the grid would appear greatly anode. There were many variations of this the electrons had to travel from cathode to determined the frequency limits of the valve in
Thyratron a pulse modulator	This was a high power mercury vapour triode used as for transmitters
Wave guide carried over at all well. sometimes gold plated carry much more length of the loss of performance. frequency of the cross section	At lower frequencies, radio signals can be successfully copper wire. At higher frequencies this does not work Waveguide is rectangular section metal tubing, on the inner surfaces. UHF and higher radio signals effectively along the inside of waveguide material. The waveguide can be many metres without significant The dimensions of the cross section must relate to the transmitted signal. A 3 cm transmission uses 3 cm waveguide for example.
Wave guide horn signal leaves the aperture or horn. For horn is located at the the nearest point of	See wave guide. At the antenna, the transmission waveguide and is directed to the antenna via an example, if the antenna is a parabolic reflector, the focal point, which may be up to 50 centimetres from surface of the reflector.
Yagi array Essentially it is a mast in horizontal	An antenna array named after its Japanese inventor. straight rod pointing away from the ship's orientation. The active element which is connected to the transmitter is a transverse element, generally

about 30% along the rod from the mast end. Nearest the mast are 2 or 3 transverse elements, slightly longer than the active element. These are the reflectors. Then progressively located away from the active element in a forward direction, each slightly shorter than its predecessor and the active element are the directors. The net result is a highly directional antenna. Yagi antennas are common in domestic free-to-air television set ups.

Early Days

In 1935, the Royal Navy's (RN) most advanced method of detecting distant objects such as enemy ships and aircraft was 7 power binoculars. Four years later at the outbreak of World War 2, the new technology known to the British as RDF and in the USA as Radio Echo Equipment, was capable of detecting an aircraft up to 60 nautical miles distant. Later the Allied forces used the common terminology of Radio Detection and Ranging, which became better known by its acronym RADAR.

Radar was not invented. It was a progressive development of concepts in the UK, the USA, Germany, Japan, France and Italy over a period of perhaps thirty years. These developments focussed on the four main components of a radar system, namely a radio transmitter with a pulse generator, an aerial array to send and to receive the electromagnetic pulses, a receiver to amplify and interpret the echo pulses, and an indicator, such as a cathode ray oscilloscope, on which to display the results for human interpretation.

In the early part of the 20th century, knowledge of developments in different countries was shared. A prime example is the Japanese-developed Yagi directional aerial [why was this important. I know, but will the reader?]. However, it became apparent that the knowledge being accumulated could be of vital security importance, and a veil of secrecy spread over the whole process in all of the technologically advanced countries from early 1930 onwards.

In February 1935 during British experiments, an aircraft was detected at a range of eight miles as it was flying within the beam of the British Broadcasting Commission's 50 metre short wave station at Daventry. Recognising the requirement to create high powered transmitters operating in the ultra shortwave spectrum, British experimental work resulted in laboratory models [of what?]which operated at 50 centimetres, and a magnetron valve capable of working at 36 centimetres. However, at this stage, these were a long way from being incorporated in operational equipment.

The RN fundamental operational concept was that radar should be used for early warning, and that the conventional range finding process of an optical range finder would then be used to track and engage the target. To this end, the stated RN requirement was to have radar which would give early warning of aircraft at sixty miles and ships at ten miles. A further requirement was that the radar would provide precise location of aircraft at ten miles and of

ships at five miles.[endnote required] The RN required short wave equipment, because longer wave equipment meant longer and bigger aerial systems which, while achievable on land, were impractical in a ship. So the RN development focus was on equipment operating in the S, C and X bands, that is wavelengths between 3 and 30 centimetres.

The first British operational seaborne radar was the Type 79, which was first fitted in the battleship *Rodney* and the cruiser *Sheffield* in early 1938. Trials conducted in *Sheffield* recorded detections of aircraft thirty miles distant at 3,000 feet [insert metric equivalents for feet], forty-eight miles distant at 7,000 feet and fifty-three miles distant at 10,000 feet. [endnote required] By May 1939, more efficient transmitting valves improved these figures by an average of 33 percent. However, as shorter wavelength equipment was still very much in the development stage, the RN had to be content with the Type 79 until 1940, when the Type 281was introduced, followed by the Type 271 in 1941. [Is there any explanation for the RN type terminology used?] During this intervening period, the Type 79 underwent a number of modifications, improving its range, power output, and general capability.

Although the UK had an operational RDF system in 1937, it wasn't until early 1939 that Australia took an active interest in this secret technology. Throughout all of 1939, there was much highly secret correspondence between such luminaries as Australia's High Commissioner to UK, Stanley Bruce, the two Prime Ministers, Joseph Lyons (who died in 1939) and Robert G. Menzies, Australian Cabinet ministers, senior officers of Australia's armed forces, and members of Australia's Radiophysics Board. A key person in this latter organisation was Dr. D.F. Martyn, DSc, PhD, ARCSc, FRMetS, FInstP, who was sent to UK to investigate and to report. [endnote required] In March 1939 Dr. Martyn sent a telegram to Lyons recommending that some of the British radar equipment should be purchased. The Prime Minister immediately authorised an order to be placed and one of the first recipients of the equipment was HMS *Amphion*, destined to become HMAS. *Perth*. [I've just written a book about *Perth* and I've found no evidence whatever to support this statement. I'd love to be proven wrong, but I need to see the chapter and verse.]

Following Dr. Martyn's UK visit, a top level Australian government committee was formed to evaluate aspects of this new technology, Radio Location. The committee decided that a Radiophysics Laboratory should be established in the grounds of the University of Sydney. A further decision was that Australia should develop equipment as an alternative to relying on UK production and availability. [endnote required] These recommendations were fully supported by the Australian government, and steps were taken to implement the establishment of the required procedures. In broad terms, the Radiophysics Laboratory became responsible for the design and development of prototype equipment, for the training of senior personnel of the armed services and their respective support functions, and in providing training in the various scientific aspects of the operation of the equipment. The Post Master General's Department became responsible for advising the Radiophysics Board on the types of equipment required, and for the installation, operation and maintenance of the equipment.
[endnote required]

The laws of supply and demand being no different for Radio Location than for any other commodity, coupled with Britain's preoccupation with the war in Europe, meant that availability of equipment for the Australian armed forces was extremely limited, which promoted the need for self sufficiency. To this end, contracts were let to Amalgamated Wireless Australia (AWA), and to STC (Australia) [Is STC and acronym for something?] for the manufacture of units of Radio Location models, which soon became known as 'radar'. [endnote required]

One of the first sets produced for the Royal Australian Navy (RAN), was the A272, [what purpose was this designed for?] which did sea trials in HMAS *Kybra* in November 1942.[endnote required] In May 1944, an upgraded version of the A272 - the A276 - did sea trials in HMAS *Yandra*. [endnote required] The comparison by PORM "Jake" Kerr of these two radars appears later in the article. Pre-war, *Yandra* and *Kybra* were small coastal steamers. Both were requisitioned by the RAN, fitted with a 4 inch gun, port & starboard antiaircraft guns, and depth charge racks aft. From 1942 on however, their prime role was as training vessels for radar operators, and for this they were equipped with British Type A286 forward and aft, the AustralianA272 forward and aft, and E271[what was this and where did it come from?] aft. The E271 was replaced by type A276. As well an A79 [what was this and where did it come from?] was fitted for the purpose of providing performance assessment for the radar maintenance personnel known as the 'Bailey Boys', of which more later.[endnote required, and what happened to the Bailey Boys?]

Radar Equipment in HMA Ships 1939 – 1955

Many HMA Ships were fitted with radar, but only the larger vessels have been included in the following list. Vessels such as the Fairmile B motor launches, and requisitioned ships such as *Ping Wo*, *Poyang* and *Yunnan* are not included. [Why not? And if ships didn't have any radar, I think they should be excluded]

Ship Name	Class of Vessel	Radar Sets
	[The letters after ship names seem to relate to their classes. Why is this significant?]	[There a lot of radars here that the reader has not yet been introduced to. I think they and their virtues should be discussed before appearing in this list]
Adelaide	Cruiser (ITC)	271. A290. SC.
Arunta	Destroyer (T)	285. A286. 293. 974. SC. SG.
Australia	Cruiser (C)	A286. 960.
Barcoo	Frigate (R)	
Barwon	Frigate (R)	
Bataan	Destroyer (T)	285. 286. 293. 974. SC. SG.
Bathurst *	AMS (Corvette)	A272. 276. A286
Bungaree	Aux Minelayer	
Burdekin	Frigate (R)	
Canberra	Cruiser (C)	271. A290
Condamine	Frigate (MR)	
Culgoa	Frigate (MR)	
Diamantina	Frigate (R)	
Gascoyne	Frigate (R)	

Hawkesbury	Frigate (R)	
Hobart	Cruiser (ML)	276. 277Q. 281AEW. 282, 285, SG.
Kanimbla ‡	AMCruiser	A290
Kybra	Patrol	
Lae	LST	
Labuan	LST	
Lachlan	Frigate (R)	
Macquarie	Frigate (R)	
Manoora ‡	AMCruiser	A290
Moresby	Survey & Escort	
Murchison	Frigate (MR)	
Napier	Destroyer (N)	271. A286. 291. SG.
Nepal	Destroyer (N)	271. A286. 291. SG
Nestor	Destroyer (N)	271. A286. 291. SG
Nizam	Destroyer (N)	271. A286. 291. SG
Norman	Destroyer (N)	271. A286. 291. SG.
Parramatta	Sloop (IG)	
Perth	Cruiser (ML)	A286 [I’ve got the leter from Waller complaining that his three new sets were not fitted before she sailed for Java. Any good to you?]
Quadrant	Destroyer (Q)	262. 277. A286. 293. 974.
Quality	Destroyer (Q)	A290
Queenborough	Destroyer (Q)	A286
Quiberon	Destroyer (Q)	285. A290.
Quickmatch	Destroyer (Q)	A290.
Shoalhaven	Frigate (MR)	
Shropshire	Cruiser (C)	273. 277Q. 281. 282. 283. 284. 285. SG.
Stuart	Destroyer (S)	A290.
Swan	Sloop (G)	
Sydney III	Aircraft carrier	277. 293. 960. 984
Sydney II	Cruiser (ML)	262
Tarakan	LST	
Tobruk	Destroyer (B)	275. 293
Vampire	Destroyer (V&W)	A290.
Vendetta	Destroyer (V&W)	286. A290.
Vengeance	Aircraft carrier.	
Voyager	Destroyer (V&W)	A290.
Warramunga	Destroyer (T)	285. A286. 293. 974. SC. SG.
Warrego	Sloop (IG)	A286.
Waterhen	Destroyer (V&W)	
Westralia ‡	AMCruiser	A290
Yandra	Patrol	276
Yarra (G)	Sloop	

* 56 Australian built Australian Minesweepers (Corvettes)
‡ Converted to Infantry Landing Ship (ILS) 1943.

B. Battle class
C. County class
G. Grimsby class
IG. Improved Grimsby class
ITC. Improved Town class
ML. Modified Leander class
MR. Modified River class

N. N class
Q. Q class
R. River class
S. Scott class
T. Tribal class
V&W. V&W Class

World War 2 Wireless & Radio Mechanics

In September 1939, Australia followed Britain and declared war on Germany. At that time, the impending hostilities were half a world away, and posed little threat to Australia. In December 1941 when the Japanese launched their assaults on nations bordering the Pacific Ocean, matters changed dramatically. Instead of being an aggressor [Who us? I thought the Germans and the Italians were the aggressors] in a conflict 12,000 miles away, Australians were faced with the task of defending their domain from attack by a powerful, fiercely aggressive, determined and very close invader. [Maybe, but what has this got to do with radar?]

Traditionally and for organisational purposes, the RAN had branches of Engineering, Gunnery, Navigation, Communications, Supply, Electrical and Medical. Within the Communications branch there were visual signalers - Signalmen, and Telegraphists. The Telegraphists' main role was to operate the wireless telegraphy equipment communicating by Morse Code. Their subsidiary role was to maintain the equipment which, in the immediate pre-war days, was fairly simple.

The challenge to 12,000,000 [There were only about 7.5 Million] Australians of defending their vast land area encompassed by about 4,000 miles of coast line, equipped with meagre and largely outdated defence technology [Are you sure about this? If you want to develop this theme, you have to demonstrate how Australian military technology lagged behind the British, for example] was daunting. To meet the challenge, many initiatives such as accelerated recruitment into the three armed services and mobilisation of industry to support a war effort were implemented. In the total context of this scenario, one of the many initiatives was the creation of a new branch of the Royal Australian Navy, the Wireless Mechanic branch. [Don’t care much for this paragraph, as you can tell. Consider confining the discussion to the development of technology and the need for personnel skilled in maintaining and operating it effectively]

By the early 1940s, the Telegraphists quickly found that the demands on their time and skills to handle the substantial increase in wireless traffic, as well as to man and to implement a training program to meet the needs of the sudden big increase in recruits, was becoming more difficult as each month passed. Coupled with this, there was a steadily increasing introduction of more technologically complex electronic equipment to the ships and shore establishments. It soon became clear that the maintenance role of the Telegraphist could not continue. To address this need, the new title of Wireless Mechanic was conceived late in 1941, and introduced to the RAN early in 1942 (CN0194/42 refers).[I have the 1/4ly letter from the Engineer of *Perth* screaming out for a mech for the Type 286 radar. Any use to you?]

To create the new Wireless Mechanics, selected personnel were to be given a basic training course of six months duration at the Melbourne Technical College, later known as the Royal Melbourne Institute of Technology (RMIT) on the principles of electronics. This was followed by equipment training at the RAN shore establishments of HMAS *Rushcutter* and HMAS *Watson* in Sydney, and at HMAS *Harman* and the Belconnen transmitting station, both in Canberra. A few of the selected personnel came from existing naval ranks, but the majority were recruited from civilian life. These then became what we know today as the Hostilities Only Radio Mechanics (HORMs).

The task of the Wireless Mechanic was to install and to maintain wireless equipment, but particularly the new radars. As the title 'Wireless Mechanic' was no longer completely described their responsibilies, in 1943 the maintainers' title was changed to 'Radio Mechanic' (RM) and the new specialists became responsible for the satisfactory performance of all electronic equipment in their ships.[i] Thus, within the space of twelve months intensive training, the RM had graduated to having the responsibility of keeping all of a warship's Radar and communication equipment fully functional.

Typically, the recruits were in their early 20s, and had secondary school education to Year 5 level. Good passes in mathematics and physics were preferred. There were exceptions such as older recruits with a strong background in radio. Following the mandatory medical examinations and probity checks, the new recruits spent their first six weeks in the Navy 'square bashing' at HMAS *Cerberus,* the large naval training establishment at Crib Point, Victoria. Those six weeks instilled a sense of discipline in each recruit, and taught him some of the basics of Navy life. The recruit learnt how to wear and to look after his uniform correctly, how to carry out the various drill orders, and generally to understand the subtleties of Naval routine. [endnote required]

All RAN recruits had this initial indoctrination, which was then followed by specialist training at the various schools within *Cerberus*. For example, the Telegraphists went to the Signal
School, the Stokers went to the Engineering School and so on. However, the Radio Mechanics were drafted to HMAS *Lonsdale*, a shore establishment located at Port Melbourne, which became their home for the next six months. Every Monday to Friday, having had breakfast, they would travel to the Melbourne Technical College, for instruction in electricity, and in radio transmission and reception. The travel distance was not far, perhaps seven kilometres, and for the earlier classes was on the back of an open tray 3 ton truck. Passenger comfort and safety were given a low priority, but some later classes had the luxury of travelling by tram. [endnote required]

Not all RMs were billeted at *Lonsdale*, since there were occasions when the population exceeded the capacity of the naval accommodation. When this occurred some RMs were billeted out in private residences, such as their own home if they had lived in Melbourne prior to enlistment. [endnote required]

What happened subsequent to the basic training depended upon two factors. One was the instructors' assessment of each student's potential, and the other was the manpower needs of the Navy. Most graduates were

very keen to be given the training which would lead them to a sea going ship. However, there were a number of shore based manning requirements, such as the Naval Transmitting Station at Belconnen Canberra, HMAS *Melville* in Darwin, and HMAS *Magnetic* in Townsville. As well, the advanced training in radar was carried out at HMAS *Rushcutter*, and later at HMAS *Watson* when that establishment was commissioned. So quite a few RMs missed the glamour and excitement of being on the front line with the enemy.

It is estimated that 363 men qualified as RMs in the period January 1942 through August 1945. [endnote required] HORMs were assigned to 194 ships and shore establishments between 1942 and the end of 1945, of which122 were sea going vessels.

In early 1945, the RAN recognised that with the imminent cessation of hostilities, most of the Hostilities Only (HO) sailors would be demobilised, potentially leaving the essential services the maintained unmanned. To address this eventuality, a recruiting program of 12 years continuous service was introduced later in 1945 for all branches of the service. An estimate of the number of RMs necessary to man the post war Navy, showed how critical the situation was deemed to be, with an estimate of just 5 serving members who would transfer to the permanent forces, leaving a shortage of 152. [ii] The schedule indicated that 101 of these 157 RMs would be destined to serve in the 54 naval vessels in commission at the time, 33 would serve in shore establishments and there would be a 'pool' of 14. DTSR [spell out] subsequently revised this estimate upwards to 285. However, eight months later on 25 April 1946, the CO of HMAS *Watson*, Commander Neil McKinnon, proposed a total of 171 RMs to man 36 ships and 11 shore establishments. This program called for a selective recruitment to induct fifteen classes at the rate of eight classes per year. Class duration was to be 39 weeks: in fact it became 49 weeks.[endnote required]

Following recruit training at HMAS *Cerberus*, trainee RMs spent six months based at the shore establishment HMAS *Torrens*, Port Adelaide. Daily they would be transported to the then School of Mines, later to be absorbed into the University of South Australia, for basic training in electrical and electronic theory and practice. Graduates were then sent to HMAS *Watson* for training in Radar or W/T equipment, according to the manning needs at the time. It was considered to be too onerous to expect the students to learn all of the W/T and Radar equipment at the time. So there was initial specialisation in W/T or Radar, with cross training a year or so later.[endnote required]

The first class commenced training at the School of Mines in January 1946, and the last completed the initial training in April 1949. During this forty month period, approximately 180 RMs graduated from the School of Mines training program. Commander McKinnon's crystal gazing 3 years previously proved to be remarkably accurate. Subsequently, the Radio Mechanic branch was folded in to the Electrical branch, and different conditions were introduced to meet the changing needs of the service. [endnote required]

Radar Officers

While a program was in hand to generate the personnel to install and maintain radar equipment in ships, the RAN also recognised the need for officers to lead the new branch. The following is an account of the experiences of the first officer recruited specifically for this purpose, Lieutenant (SP) David Medley RANVR.[iii]

I was the first officer recruited directly into the RANVR for RDF duties on 1 November 1941. This was in response to an ad which appeared in the Melbourne papers around September 1941. At that time I was the only one recruited and I suppose probably the only applicant at that time. I was transferred to the Admiral's staff in Sydney where I was assigned to the Flag Lieutenant, Lieutenant Commander John Bath. Also on this staff was a Warrant Officer by the name of Jock Smart. Jock was a Telegraphist and had been assigned for RDF duties. He knew very little about RDF and was happy to have me aboard. Little did he know that I knew nothing about it either but I did have a Masters Degree in Physics, had been a ham radio operator for some years, and interested in electronics as far back as I could remember. This deficiency was soon rectified as I was given a crash course at the Radio Physics laboratory and access to all the classified material the RAN had at that time , which I absorbed like a sponge. After a sojourn at Flinders where I was supposed to learn how to be an officer, I was assigned to help with the RDF installations on *Canberra*, presently refitting at Garden Island. On completion of this work early in 1942 I was assigned to her as RDF Officer. Subsequent events were recorded in 'The Shame of Savo', so I will not repeat them here.[iv]

I have only the haziest recollection of the "Bailey Boys" as I never had anything to do with the training school at HMAS *Watson*. I do recall that after I returned from the Savo affair, four RAAF officers and four RAAF mechanics were loaned by the RAAF to assist in the training of RDF operators.

Also about this time (late 1942), a distinguished A/S officer, Lt Tom Cree DSO, returned from Europe and was assigned OIC of the RDF section in Navy Office Melbourne, and I essentially worked for him for the remainder of my stay in the Navy.

Even at this time I was the only officer with a firm technical background and I suppose I was regarded as something of a "Whiz Kid". In any event I was frequently called upon to work on installations which had been beyond the capabilities of the personnel concerned. I remember working on the RDF installation on *Queen Mary* while she was in Sydney. I remember working all night on an obscure fault in a gunnery control Radar on *Warramunga*, and I remember being sent to service RDF equipment on board a royal Dutch cruiser called *Van Tromp* [HNlMS *Tromp*] in New Guinea. I remember vividly a spell in Brisbane with a US Navy submarine tender which was installing gunnery control Radars on *Australia* and *Hobart*. I was the liaison between the RAN and USN and I can recall that this was a fun time, and I learned a lot more about Radar from a Westinghouse Field Engineer who was supervising these installations.

I remember being sent to the USN PT boat bases on Guadalcanal and Savo Island sometime in 1943 to learn as much as I could about the SO Radars

which the RAN had purchased for installation in the Fairmiles. These were subsequently installed at *Rushcutter* and I would suppose I supervised at least the first several installations. My most vivid recollections of this period were an overnight stay with a bunch of Coast Watchers who were waiting to be picked up by a submarine and deposited behind enemy lines and a ride on a PT boat from Guadalcanal to Savo.

As to the laboratory, I was nominally in charge of it while it was at *Rushcutter* from the time I returned from *Canberra* until I left the Navy in late 1945. I say nominally because I was away on special assignments a great deal of the time. On the other hand Alan Young was there all the time and will remember a lot more detail than I. The functions of the lab were as far as I can recall:

1. To provide a test facility for acceptance testing of Radar equipment being built in Australia.

2. To maintain a set of accurately calibrated test instruments which could be used to maintain standards of accuracy at RAN service bases.

3. To test new Radar equipment from overseas and to become familiar with it before it was installed in ships.

4. To develop new ideas as appropriate. In this area I worked on a Doppler Radar idea which has just now become a hot topic here in the USA. I also worked on Radar jamming equipment in the latter part of the war.

In 1945 it was decided to transfer the lab to *Watson*, and Alan and I designed a building for it. Whether this was ever built I am not sure but I do know the lab was never transferred to *Watson*, but was reinstalled out at the Navy Stores facility at Leichhardt sometime in 1945 – 46.

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Radar Equipment HMAS *Shropshire*

As the Pacific War progressed more and more RAN ships were progressively fitted with radars of various kinds, from British, Australian and US sources. The peak of the state of the art as it was in those days was achieved in HMAS *Shropshire*, a County Class heavy cruiser transferred to the RAN by the RN to replace her sister ship, HMAS *Canberra*, lost as a result of the Battle of Savo Island on 9 August 1942. The following description of her radar outfit has been provided by Lieutenant (SP) R. Slatyer R.A.N.V.R. Radar Technical Officer, HMAS *Shropshire* from October 1943 to January 1946

When *Shropshire* was being prepared in England for handing over to the RAN in 1942/43, she was fitted out with a full complement of the current

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[i] Commonwealth Navy Order 414/43.
[ii] dated 13 August 1945 and promoted by DTSR Captain Alan McNicol
[iii] Letter written 19 September 1995 by Lt (Sp) David Medley RANVR to John Saywell OAM, president of the RAN Radio Mechanics Association)
[iv] Bruce Loxton, *The Shame of Savo*, Chapter 8 “Preliminary Moves” pages 62 on, and Chapter 23 “The Verdict” pages 254 on

R.N. equipment. The following list of equipment in numerical order of type number includes other equipment installed later.

- Type 273. SURFACE WARNING. Wavelength 10 cm (Frequency 3,000 Megacycles). Located just forward of the after control position. Antenna gyrostabilised, located in a “lantern” structure directly on top of office. Also connected to an accurate range display panel in the T.S.
- Type 277. AIRCRAFT TRACKING. Wavelength 10 cm. fitted during a refit in mid 1945. Antenna on foremast. Office in new extension on port side of bridge structure. Single “dish” antenna controlled for both elevation and bearing enabled this equipment to provide information on the exact location of an aircraft.
- AIR WARNING. Frequency 90 megacycles. Transmitting antenna on mainmast with transmitter in office at base of the mast. Receiving antenna on foremast with receiving office on flag deck at base of mast. Antennas rotated in synchronism. The 281 was undoubtedly Shropshire’s most important radar unit! More on this later.
- Type 282. For control of multiple pom poms, one set for port and one for starboard.
- Type 283. AUTO BARRAGE UNITS. One for each turret. Each set had a control station with display unit on the upper deck. Main office below decks. The purpose of these sets was to enable efficient use of the main armament against dive bombers. We found them quite useful when there were *kamikazes* around.

  Each of these sets was equipped with a small fire control device – a sort of mechanical computer. When the main armament guns were loaded with shells fitted with a time fuse, generally set for a different time in each barrel, this device would calculate the correct time and fire the gun so that the point at which the shell exploded was the point at which the aircraft would be if it continued on the same course and speed.

- Type 284. GUNNERY CONTROL MAIN ARMAMENT. Antenna mounted on the main armament director. Office below decks, accurate range display panel in the TS provided range and bearing for main armament fire control.
- Type 285. 4 INCH ANTI-AIRCRAFT GUNS Antenna mounted on after director – high angle control position. Office below decks. Provided range and bearing for anti-aircraft fire control.

Power supplies to all of the gunnery control radars were combined in an integrated system. All sets operated at the same frequency, around 600 Megacycles. Power was supplied from a large motor alternator set with output 180 volts at 500 cycles, which was their pulse repetition frequency, and interference was avoided by having a phase difference between the power supplied to each set.

- Type SG. An American unit of 10 cm wavelength fitted soon after we joined the 7th Fleet. Antenna on foremast, PPI display in plot below bridge. Used for surface navigation as well as surface warning.
- RADAR COUNTER MEASURES. Equipment consisted of multi-band receivers and a type 91 jamming transmitter.

CAPABILITY REPORT

During service in the New Guinea and Philippines campaigns HMAS *Shropshire* achieved a reputation for, among other things, the efficiency of reporting aircraft movements (Editor's note, see appendix below).[v] I will attempt to explain, briefly, how I consider this was achieved.

This efficiency was due to a combination of:-

- The nature of the equipment
- Maintenance and tuning
- Skill of the operators
- Efficiency of the plotting office
- Team work

Nature of the equipment. The primary air warning radar was Type 281. This was a rugged piece of equipment built in the style of the R.N. long range W/T sets. The output stage of the transmitter gave an impression of power with quartz "tubes" about 12 cm. in diameter and 40 cm. long. The transmitting antenna was on the mainmast and the receiving antennas on the foremast. They were broadside style arrays with timber frame, ceramic insulators, and aluminium dipoles. The feeder for the transmitter was of twin wires held apart by plastic insulators. The receiver feeder was "Pyrotenax". On the flag deck at the base of the foremast was the receiving office. In this were all components of the receiver, including the display and the controller for rotation of the antennas as well as the telephones.

Maintenance and tuning. Because of wartime shortages in England, the materials used for the construction of exposed parts were not always as durable as they could have been. This factor, added to the severity of the tropical conditions in which we were operating, resulted in the need for frequent maintenance work to maintain peak performance. Careful attention was given to this, which included much masthead work, varnishing woodwork and cleaning insulators – even on one occasion, at night in the tail end of a typhoon, to wash off salt spray which was causing sparking while the ship was darkened. As regards tuning, one feature of the 281 was that most units where tuning was critical were designed so that they could be tuned to maximise performance. This is different from many other radars where such units are preset and changes over time can adversely affect performance.

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[v] Gill, *Royal Australian Navy 1942 – 1945*, P536: "The American destroyer *Ammen* referred to the superb Radar telling performed so steadily and reliably by the *Shropshire* during the operations against the enemy just completed. The information provided by 'Porthole' (*Shropshire's* communication designation) was of inestimable value in maintaining the *Ammen* alert and ready to deal with the Nips at all times"

'Further, in a letter to Captain Nicholls, Admiral Weyler remarked that "Commander Task Group 77.1 concurs that *Shropshire's* performance in radar telling was outstanding and takes this opportunity to congratulate her Commanding Officer, and all officers and men who contributed thereto. As a matter of fact *Shropshire's* excellent performance in subject matter has heretofore been attested in reports submitted to Superior Command.

As well, pages 182 and 183 of Stan Nicholls book "HMAS *Shropshire*", published by the Naval Historical Society of Australia December 1989 (ISBN 0 958 7456 2) quotes a number of high commendatory remarks about *Shropshire's* radar efficiency, made by senior officers of the USN, & RN.

Skill of the operators. The display was a cathode ray tube about 15 cm in diameter, known as an “A” scan. (Editors note: See description of “A” scan in the chapter “Radar Basics”). The operator had control of the rotation of the antennas, which rotated in synchronism, and he would adjust the angle of the antennas relative to the fore and aft line of the ship to maximise the “pip” and find the bearing of the aircraft. Some refinements in technique would provide an estimate of the height of the aircraft.
This information would be telephoned to the Plotting Office. To accurately maintain reports on a number of aircraft on this type of equipment required a great deal of skill on the part of the operator. There would be two operators on watch and they would relieve each other from time to time. *Shropshire* was fortunate in having a number of men with this ability.

Efficiency of the Plotting Office. As well as receiving the reports of aircraft detected by the ship’s radar this office was in communication with other ships in the fleet, friendly aircraft and shore bases. Reports of aircraft positions were plotted on a large board. At times a great deal of information was processed and personnel became very skilled. The officer in charge was of a temperament well suited to his position. *Shropshire’s* callsign was “PORTHOLE” and this name became famous as a source of information on warnings of hostile aircraft.

Team work. As with all operations in a fighting ship the overall efficiency depended on team work. In *Shropshire* there had been very few changes in personnel and all members of the ship’s company had learnt to work together. This undoubtedly was an important factor in all operations. Perhaps the reports that she was a “Lucky Ship” also had some validity.